BOOK REVIEWS

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Beetle Larvae of the World: Interactive Identification and Information Retrieval for Families and Subfamilies.—J. Lawrence, A. Hastings, M. Dallwitz and T. Paine. 1993. CSIRO Information Services, P.O. Box 89, East Melbourne, Victoria 3002 Australia, CD-ROM disk and 52-page manual. $240.00.

This system results from the combined application of new computer technologies to the field of systematics. An extensive database of information on larval Coleoptera was compiled using the DELTA (DEscription Language for TAxonomy) system (see Dallwitz, 1980, 1993). The package employs the INTKEY system (Dallwitz, 1993) to allow interactive access to the complete database at each step of the identification process rather than restricting one to a handful of available characters as with traditional, dichotomous keys. In this way the program works as a synoptic key, the advantages of which are discussed by Korf (1972) and Leenhouts (1966). In addition to the natural marriage of computers and synoptic keys, the system benefits from recent advances in CD-ROM technology which make extensive databases and collections of memory-intensive figures available to most PC users.

Already there have been many uses of the DELTA system for generating data matrices and standardized descriptions. These have been largely botanical and viral applications although some exist for hexapods such as Collembola (Christiansen et al., 1990), Hymenoptera (Taylor, 1978, 1979, 1990) and Coleoptera (Britton, 1986; O'Brien and Askevold, 1992). To date, Christiansen et al. (1990) and Taylor (1990) are the only other hexapodan applications also employing INTKEY, the interactive computer identification and information retrieval system.

The heart of the program is a matrix of 180 characters by 385 taxa. Much of the matrix is made up of multistate characters with as many as 17 states. Identifications terminate at various taxonomic levels ranging from family to genus. In Erotylidae, for example, the matrix contains the following four taxonomic groups (i.e., possible determinations): Erotylidae (major part), Dacnini, Megalodacnini and *Microsternus*. Taxa which vary greatly from instar to instar or which have radically different larval forms (e.g., caraboid, cerambycoid and paedogenetic forms of Micromalthidae) have multiple entries in the database.

Aside from its utility as an identification tool, this expert system also functions as a database of Coleopteran larval information. Six text "characters" in the matrix are used solely for retrieval of information about taxa including geographical distributions, taxonomic synonyms, biology, larval bibliographic references and figures available in the program. The morphological characters can also be searched, sorted and easily accessed using the various functions.

Information in the database is current and as factual as the published literature permits, but due to the present fragmentary state of our knowledge of Coleoptera larvae, some inaccuracies will surely be found for many groups. At present we cannot assess the phylogenetic importance of each character. As such, generalizations about

character states for higher taxonomic groups will be expanded to include additional states as the larvae of other species are described.

This situation, not surprising for a study of this scope on holometabolous larvae, is ameliorated by the INTKEY program with adjustments of "tolerance levels" to give the identification process varying degrees of confidence. If a specimen fails to be determined with relative certainty, the tolerance level can be adjusted so that taxa are not immediately excluded when a conflict between the specimen and the data matrix occurs. Instead, taxa can remain in consideration as potential solutions until their character data conflict with the specimen twice (or as many times as desired). If a character state choice at one step of an identification excludes all remaining taxa, INTKEY automatically adjusts the tolerance level to reconsider those with the fewest conflicts.

Of the 385 taxa included in the matrix, 206 are illustrated. Many figures are familiar as most apparently have been scanned from the major works on Coleoptera larvae such as Costa et al. (1988), Lawrence (1991) and Lawrence and Britton (1991). Computerized coloration of the images makes them three-dimensional and attractive. Three images are scanned from color photographs of larvae in natural surroundings and are quite impressive.

To aid in making determinations, various INTKEY functions assist in understanding the characters. At any point in the determination process, if a character is unclear, one could have the program list the possible states or provide additional notes describing it. The greatest help in understanding the characters, however, is the collection of superb character images available for viewing at any time. Of the 180 characters in the matrix, 110 are illustrated. Most of the images apparently were scanned from Lawrence (1991) and were enhanced with shading and color to make them more attractive and to highlight relevant structures. In two of the images, character states are illustrated effectively with a set of scanning electron micrographs.

My only regret about the graphics is that there are not more taxonomic images included. Many small and obscure groups are not represented. Instead the user is provided with either a screen stating that no figure is available or an image of a superficially similar larva (clearly described as such). An image of a larval *Parandra* sp. is used to give a superficial representation of eight taxa other than the genus itself. For large or diverse families such as Staphylinidae, illustrations of several additional taxa would be appreciated.

The program facilitates making determinations in many ways. Some of its features are best explained through example. Beginning with an undetermined larva, the Beetle Larvae of the World program has 385 possible determinations. To begin one could use the first true (non-text) characters which are simple and refer to overall size and shape of the specimen. Alternatively, one might recognize that the specimen is, for example, a cucujoid and eliminate all other taxa from the analysis, leaving 77 taxa.

At this point, one could restrict the key to only those characters that are useful in distinguishing the remaining taxa by using the "Best" function which chooses characters with the highest reliability (based on how "clear cut" the states are) and with the best ability to separate the taxa in consideration. The key in the example is thereby reduced to 145 relevant characters and a measurement of the "separating power" of each for the remaining taxa is provided.

To begin using those "Best" characters, one could start with those at the beginning of the list (the best of the best) or with those that are most familiar. Another approach would be to use a suite of characters pertaining to one structure. For example, you might have slide-mounted mandibles in focus at the moment. The "Find" function could quickly identify the nine relevant characters pertaining to mandibles. This could also be accomplished with the "Use" function and a selection of the keyword "mandibles." After scoring the example specimen for the mandibular characters, only three taxonomic determinations remain in consideration: *Endomychus,* Erotylidae (major part) and Megalodacnini.

At this point, one could move to another convenient suite of characters or pick favorite characters from the list of those remaining. A more efficacious approach would be to use the "Best" function again to list the characters that are capable of separating the few remaining taxa. A total of 58 characters are suggested to further separate the remaining 3 taxa. While scrolling through the list of character names, one may use the ALT + S(tate) function to view a list of the states available for each character.

The example specimen has many conspicuous processes arising from its dorsal and pleural regions so you choose character 113 which asks if such processes occur on the thorax. An affirmative answer eliminates Megalodacnini.

You now ask for the best characters to separate *Endomychus* from Erotylidae (53 characters are suggested!). You choose character 172 referring to the form of the thoracic spiracles and use the ALT + I(mage) function to see figures of the various states. The specimen has annular-multiforous spiracles, identifying it as an erotylid larva.

This determination could be confirmed by using the "Diagnose" option and by viewing the image of an erotylid larvae. Information about Erotylidae such as distribution, biology, synonymies and larval literature references can be perused in the six text characters of the matrix using the "Describe" function. Hard copies of a session can be obtained by using the various functions provided for customizing output of files and subsequently importing, editing and printing them with word-processing software.

To use this system, the following computer equipment is required: an IBM-compatible PC, at least 640KB of memory, a hard disk, MS-DOS version 3.1 or higher and Microsoft MS-DOS CD-ROM Extensions version 2.1 or higher. A super VGA card and monitor capable of 640 × 480 resolution in 256 colors are needed to view the graphics. The video card should comply with the VESA standard or use the TSENG Labs instruction set, although other cards might work satisfactorily. It was reviewed on a Gateway 386/25C system with the following : NEC Intersect CDR84 CD-ROM reader, Adaptec 1542B SCSI board, Adaptec EZ/SCSI software and Gateway 1024 N1 Crystal Scan monitor.

Installation was quick and easy with one exception. There was insufficient space in our system's RAM due to several resident programs and before the program quit and yielded to DOS, it flashed two screens so quickly that neither one could be read nor frozen on the screen despite several attempts. This made diagnosis of the problem more difficult than necessary.

In general this package is nicely produced. The documentation accompanying the

disk consists of a 52 page color booklet which is written clearly and quickly familiarizes one with the program through explanations of the major features and three example identifications. Numerous typographical errors in the manual detract slightly from an otherwise very professional package with nice details right down to the neon purple silk-screened larva on the disk.

The cost ($240 U.S.) is somewhat expensive, a problem likely to be compounded because many potential buyers will be unable to use the program without also purchasing a CD-ROM drive and video board for their systems. This package shows such promise, however, that it seems only a matter of time before that upgrade will be a necessity and a computer will be permanently positioned near the microscope.

The Beetle Larvae of the World interactive program is a perfect demonstration of the practicality and effectiveness of the DELTA and INTKEY systems. The use of synoptic-style keys on a computerized taxon/character database greatly facilitates identification. The core of the program is the most comprehensive collection of character data for Coleoptera larvae "published" to date. The package, further enhanced with many helpful INTKEY functions and a large collection of figures, is an elegant application of new computer technology to the field of systematics.—*Joseph V. McHugh, Department of Entomology, Comstock Hall, Cornell University, Ithaca, New York 14853-0999.*

LITERATURE CITED

Britton, E. B. 1986. A revision of the Australian chafers (Coleoptera: Scarabaeidae: Melolonthinae). Vol. 4. Tribe Liparetrini: genus *Colpochila.* Aust. J. Zool., Suppl. Ser. 118: 1–135.

Christiansen, K. A., P. F. Bellinger and M. M. da Gama. 1990. Computer assisted identification of specimens of *Pseudosinella* (Collembola: Entomobryidae). Rev. Ecol. Biol. Sol 27: 231–246.

Costa, C., S. A. Vanin and S. A. Casari-Chen. 1988. Larvas de Coleoptera do Brasil. Museu de Zoologia, Universidade de São Paulo, São Paulo. 282 pp.

Dallwitz, M. J. 1980. A general system for coding taxonomic descriptions. Taxon 29(1): 41–46.

Dallwitz, M. J. 1993. DELTA and INTKEY. Pages 287–296 *in:* R. Fortuner, (ed.), Advances in Computer Method for Systematic Biology: Artificial Intelligence, Databases, Computer Vision. John Hopkins University Press, Baltimore, Maryland.

Korf, R. P. 1972. Synoptic key to the genera of the Pezizales. Mycologia 64(5):937–994.

Lawrence, J. F. 1991. Erotylidae (Cucujoidea). Pages 473–475 *in:* F. W. Stehr (ed.), Immature Insects. Vol. II. Kendall Hunt, Dubuque, Iowa. 974 pp.

Lawrence, J. F. and E. B. Britton. 1991. Coleoptera. Pages 543–683 *in:* C.S.I.R.O., The Insects of Australia. Vol. II. Second Ed. Melbourne University Press, Melbourne.

Leenhouts, P. W. 1966. Keys in biology. I. A survey and a proposal of a new kind. Proc. K. Ned. Akad. Wetensch. 69C:571–596.

O'Brien, C. W. and I. S. Askevold. 1992. Systematics and evolution of weevils of the genus *Bagous* Germar (Coleoptera: Curculionidae), I. Species of Australia. Trans. Amer. Ent. Soc. 118:331–452.

Taylor, R. W. 1978. A taxonomic guide to the ant genus *Orectognathus* (Hymenoptera: Formicidae). CSIRO Aust. Div. Ent. Rep. No. 3. 11 pp. + microfiche.

Taylor, R. W. 1979. New Australian ants of the genus *Orectognathus,* with summary descrip-

tion of the twenty-nine known species (Hymenoptera: Formicidae). Aust. J. Zool. 27: 773–788.

Taylor, R. W. 1990. New Asian ants of the tribe Basicerotini, with an on-line computer interactive key to the twenty-six known Indo-Australian species (Hymenoptera: Formicidae: Myrmicinae). Invert. Taxon. 4:397–425.

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Handbook of the Fruit Flies (Diptera: Tephritidae) of America North of Mexico.— R. H. Foote, F. L. Blanc and A. L. Norrbom. 1993. Comstock Publishing Associates (a division of Cornell University Press), Ithaca. xii + 571 pp. US $115.50 cloth.

In the field of agriculture, the true fruit flies (Tephritidae or Trypetidae) are by far the most written about and researched group of Diptera, with citations far in excess of the other major phytophagous groups, namely the Cecidomyiidae and Agromyzidae. Most of that interest is confined to the major fruit pest genera *Anastrepha, Bactrocera, Ceratitis, Dacus* and *Rhagoletis,* all of which have been found in North America at some time, even if they are fortunately not all established there. However, most temperate members of the family are not associated with fruit, but with the flowers, or sometimes leaves, stems or roots, of Asteraceae (=Compositae). Most of the 300 species and 56 genera known in North America are Asteraceae-associated, and some of those are actually European species deliberately introduced to help control European plants that have been accidentally introduced into North America. The application of these flies to weed biological control has been possible because most of the Asteraceae-associated tephritids have a remarkably narrow host range, in many cases attacking only a few plants belonging to a single species group, subgenus or genus. Complex behavioral patterns in mate recognition and the use of the host plant as a mating rendezvous site have no doubt facilitated the evolution of many closely related species each with differing ranges of hosts. However, the family Tephritidae has been remarkably neglected by the major workers in plant–insect relationships, and most of our knowledge of the biology of the Asteraceae-associated species comes from the work of present or former biocontrol specialists.

This monumental work, which deserves a more prestigious title than merely *Handbook,* keys and describes all of the 300 species known from the Americas north of Mexico. It will therefore enable identification of the known pest and beneficial species, and hopefully encourage further work involving these flies in the field of plant–insect relationships. For the first two authors this book represents a synthesis of experience gained during entire career spans, supplemented by recent studies carried out by the third author, notably on the genus *Anastrepha.*

The book starts with an introduction which includes a mention of species of some biocontrol agent tephritids that were introduced too late for full inclusion in the work. There follows an excellent account of the adult morphology of tephritid fruit flies which is both well illustrated and applies the standardized terms first detailed in the *Manual of Nearctic Diptera* (J. F. McAlpine, ed., 1981). Even so, there is still